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THE RANGE OF VARIATION OF THE HUMAN SHOULDER-BLADE.

BY THOMAS DWIGHT, M.D.[1]

THE late Professor Broca read a paper before La Société d'Anthropologie in 1878[2] in which he described the scapular and the infra-spinous indices, and proposed them as methods of ethnological research. Briefly stated, the scapular index is the proportion of the breadth of the scapula, measured along the base of the spine, to the length, the latter being considered one hundred. The infra-spinous index is the proportion of the breadth to the length of the infra-spinous fossa, the latter being considered one hundred.

The human scapula being the starting-point, Broca understands by "length" the line connecting the highest and lowest points, although in almost all mammals this is not the longest dimension. The line showing the breadth being called AB and that of the length CD, the index is obtained by calculating $\frac{100 \times AB}{CD}$. The length very rarely coincides with the posterior border of the scapula, but runs some distance before it. The line AD representing the infra-spinous length runs from the posterior end of AB to the lower end of CD. The infra-spinous index is represented[3] by the fraction $\frac{100 \times AB}{AD}$. Professor Broca used these indices both in comparative anatomy and in the study of characteristics of race, sex, and age in man.

In all orders of mammals, with one exception, the scapular index is greater than in man. In quadrupeds it is evident that the long diameter of the bone should at least approximately coincide with the line of pressure, and consequently we find the breadth—*i.e*, the line along the base of the spine—the longer. In erect man, with his great range of movement of the anterior extremities, there is need of greater leverage for the movements of the scapula, and less need of resistance to pressure, so we find a long and narrow scapula. This condition is approached in the anthropoid apes, and even surpassed in the bats, who have a lower scapular index than man. Broca's observations on the characteristics of sex and race of human scapulæ are by no means satisfactory, owing to the small number of observations. The indices of adult Frenchmen were obtained from twenty-three individuals, of which nine were female; and those of African negroes from twenty-five individuals, of which five were female. Apparently one scapula was measured in each case.

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[1] Parkman Professor of Anatomy at Harvard University.

[2] Bulletins de la Société d'Anthropologie de Paris, série 3, tome i.

[3] By a most unfortunate oversight the AB and AD are transposed in Broca's paper.

The next year Professor Flower and Dr. Garson measured two hundred scapulæ of Europeans. They admit that it is quite possible that some of the bones belonged to members of other races, and they paid no attention to sex, which for the most part was unknown. They counted every scapula measured as one, whether or not its fellow came under observation. They measured also a few scapulæ of other races, but the series were for the most part very small. The largest were twenty-one Andaman scapulæ and twelve Australian.

M. Marius Livon also studied this subject at about the same time, and gave his results in his "Thèse pour le Doctorat," which appeared in 1879. I have never seen his essay, and know it only by references to it by Sir William Turner[1] and by M. Manouvrier.[2] He measured the bones of seventy-three Frenchmen and fifty-one Frenchwomen.

Negroes, Andamanese, and Australians have higher indices, which means broader scapulæ, and consequently of a lower type. Broca points out, however, in his remarks about negroes, that this is true only of the mean, and that individuals of both classes are found to vary very much from it. Indeed, the anthropoid apes may have at least a scapular index within the range of the variations of man. The greater obliquity of the spine in apes makes their infra-spinous angle more characteristic.

Broca claimed that, in spite of the great individual variation, this method is of value when applied to groups.

I began a series of measurements of human and of anthropoid shoulder-blades several years ago and put it aside for other work. I have recently resumed it. My original purpose had been simply to collect additional statistics, but as I went on I was much struck by the diversity of forms which the scapula presents, as well as by the variation of the indices. I became convinced both that the indices do not necessarily indicate the shape of the bone, and that they are worthless to determine the race of any single bone.

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[1] "Challenger" Reports, vol. xvi.

[2] Revue d'Anthropologie, 2me série, tome iii., 1880.

The one hundred and thirteen bones which I have called Caucasian are, like those used by Flower and Garson, rather a heterogeneous collection. They for the most part belong to the Harvard Medical School and to the Boston Society of Natural History. More than a few of them came from France. While they, no doubt, are in the main Caucasian, it is probable that there are some negro bones among them. Indeed, I know that two of the scapulæ came from the body of a negro. These are remarkable as presenting very low (instead of high) indices.

Through the kindness of Professor Putnam, who most generously put all the stores of the Peabody Museum of Archæology at my disposition, I had hoped to be able to present a large collection of figures from the bones of the mound-builders, and perhaps to make observations on many individuals of a race which was less mixed than most of those whose bones are easily obtained to-day. I was, however, disappointed, and from a cause that is easy to foresee, namely, the great fragility of the scapula. I could have had long bones in abundance, but the shoulder-blades were for the most part either in fragments, or so injured that the necessary measurements could not be made. I have the records of six scapulæ from California which are probably Indian, and of eighteen from the Kentucky mounds. The mean of the Californians is 67.25 for the scapular index and 91.05 for the infra-spinous. The mound-builders have a mean scapular index of 69.29 and an infra-spinous one of 93.75.

The following table shows the indices of Caucasian bones obtained by my predecessors and myself. Livon is the only one who has a tolerably large series showing the difference between the sexes. Broca, with a much smaller series, had different results:

TABLE I.

	Broca.	Flower and Garson.	Livon.		Dwight.
			Male.	Female.	
Scapular index	65.91	65.2	63.0	67.4	63.5
Infra-spinous index..................	87.79	89.4	85.4	88.8	85.8

To understand the significance of figures something more is needed than an average, which gives no hint of the range of variation, and accordingly I have arranged the figures of the indices of the Caucasians and mound-builders in groups. The first row of figures shows the index, and opposite each is placed the number of scapulæ having that figure (or that figure and a fraction) for an index. The six Californians showed no extreme figures.[1]

TABLE II.

Scapular Index.			Infra-spinous Index.		
Index.	Caucasians.	Mound-builders.	Index.	Caucasians.	Mound-builders.
55	2	...	72	2	...
56	3	...	73	...	...
57	5	...	74	...	...
58	7	...	75	1	...
59	5	...	76	2	...
60	9	...	77	4	...
61	8	...	78	4	...
62	12	...	79	8	...
63	13	1	80	7	...
64	6	...	81	4	...
65	11	2	82	6	...
66	10	3	83	5	...
67	8	2	84	4	...
68	1	3	85	10	...
69	4	1	86	7	...
70	3	1	87	10	...
71	3	1	88	5	3
72	1	1	89	3	3
73	1	...	90	8	3
74	...	...	91	1	...
75	...	...	92	6	2
76	1	1	93	2	1
77	...	1	94	5	...
78	...	...	95	2	1
79	...	...	96	3	1
80	...	...	97	1	1
81	...	...	98	1	...
82	...	1	99	...	...
			100	1	...
			101	...	...
			102	1	...
			103	...	...
			104	...	...
			105	...	1
			106	...	1
			107	...	1
Total........	113	18	Total........	113	18
Mean........	63.50	69.29	Mean........	85.83	93.75

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[1] There can be no question that in measurements the "personal equation" has its effect. No doubt the discrepancies would have been less if all the measurements had been made by one man. The very greatest care is needed to avoid mistakes. I was much mortified at the conclusion of this work to find inaccuracies in the measurements of two bones, the results of which it was practically impossible to rectify. Happily the errors are of little consequence.

The scapulæ from Kentucky have a decidedly higher index than the Caucasians, and this is evidently not due to individual peculiarities, for though three specimens with remarkably high indices have their effect on the average, yet the scapular index is only once, and the infra-spinous never, as low as the Caucasian mean.

Broca gives some of his extreme figures, which are very interesting. The bone with the lowest indices belonged to a Turk from Smyrna; the next lowest scapular index was furnished by a Frenchwoman, and the next lowest infra-spinous by an Arab. The highest indices belonged to an African negro, by name Tom Blaise, and the next to a black from Hindoostan.

Flower and Garson, unfortunately, make no mention of their extreme cases. For more convenient comparison I put my extremes below Broca's in the following tables:

TABLE III.

MINIMA.

	Scap. Index.	Infra-spin. Index.
Broca. Turk from Smyrna	57.47	75.19
Broca. Frenchwoman	60.27	......
Broca. Arab	......	78.57
Dwight. Caucasian (Fig. 4)	55.1	72.8
Dwight. Negro (Fig. 10)	58.8	72.3

MAXIMA.

	Scap. Index.	Infra-spin. Index.
Broca. Tom Blaise	76.64	111.95
Broca. Black from Hindoostan	76.61	104.39
Dwight. Kentucky Mound-builder (Fig. 5)	82.2	107.3
Dwight. Kentucky Mound-builder	77.1	106.9
Dwight. Highest scapular index among Caucasians	76.3	98.2
Dwight. Highest infra-spinous index among Caucasians	71.8	102.0

Broca thought it likely (*assez probable*) that his limits would be but rarely passed. Table II. shows, however, that I have measured no less than twenty-two bones with a scapular index below sixty, and that five of them were below fifty-seven. The two given in Table III. are, however, the only ones in which the infra-spinous index falls below seventy-five. Turning to the *maxima*, I have no equal to Tom Blaise in both indices, which is due to the great obliquity of the spine of his scapula, an ape-like feature which the mound-builders cannot rival. One of them has a scapular index which is decidedly higher, and they both exceed the black from Hindoostan in both respects.

Sir William Turner states in his "Challenger" report that, excluding the scapulæ of one Hottentot, the mean scapular index of several races ranged from 60.3 in the Tasmanians to 70.2 in the Andaman Islanders. This includes the results of some other observers. It would appear, however, that for some reason he has omitted also his four Ohauan (Pacific Islands) scapulæ, which have the extraordinary *means* of 78.8 for the scapular index and 117 for the infra-spinous. He found the variations in the scapular index of African blacks, male and female, to range from 57 to 81, and the infra-spinous index from 30 to 117.

Apart from the range of individual variation in the indices, this method is open to at least two criticisms: first, that there are various forms of scapulæ, which may not be without their ethnological significance, to which these indices give no clue; and, secondly, that the length of the scapula—which is of primary importance in determining the more important index, the scapular—depends in part on the development of the superior angle of the bone. In support of the first criticism I would call attention to two scapulæ (Figs. 6 and 7) whose indices are almost identical, yet which in shape differ enough to be bones of different species. I shall return to these points in the course of the discussion of the variation of different parts of the bone.

Length.—In the one hundred and thirteen Caucasians, all adults, the mean length is 16.22 cm., the extremes being 13.2 and 20.1. There are six under 14 cm. and ten of 18 or more. The mean of the six Californian Indians is 13.62, and of the eighteen from the Kentucky mounds 14.07. The range of variation in these two series is very small. The shortest bone is 12.4, and the longest 15.8, both from Kentucky. These old bones, both in size and shape, constitute a well-marked series.

Professor Mivart, in his well-known paper on the "Appendicular Skeleton of the Primates,"[1] takes several parts of the scapula for comparison. We shall consider the variation that some of these present in man alone.

The inferior angle (Fig. 1),[2] which Professor Mivart puts at

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[1] Philosophical Transactions, London, vol. clvii., part 2, 1867.

[2] In Figures 1, 2, and 3 the partial outlines are drawn as though taken from the bone of the right side in every case. This is for convenience.

35° or 40° in man, presents great differences, as is shown by the appended wood-cuts. I give no measurements, as the difficulty of making accurate ones is quite out of proportion to their value. The difference is in part, but not wholly, due to the development of the surface at the lower part of the axillary margin for the teres major.[1] This muscle arises from the dorsal surface of the bone, but there is almost always a slight projection at this point from the anterior border, and occasionally it is developed into a projection of considerable size. Broca states that this is more common in negroes. I have no opinion to offer on this point, but I believe that this process does not stand in direct ratio to the size of the muscle. It is well marked on a very delicate scapula (Fig. 5), and on the other hand there is a large surface to this muscle with hardly any projection on a remarkably sharp bone (Fig. 4). An analogous case is the third trochanter, the occurrence of which, in my opinion, is quite uninfluenced by muscular development. The surface for the *teres major* projects out very strongly in the lower Simiidæ, Cebas, and Chrisothrix, according to Mivart. Its occurrence in man is probably (as in the case of the third trochanter) the appearance of a peculiarity of lower forms. The lower angle, however, varies considerably apart from the influence of this process.

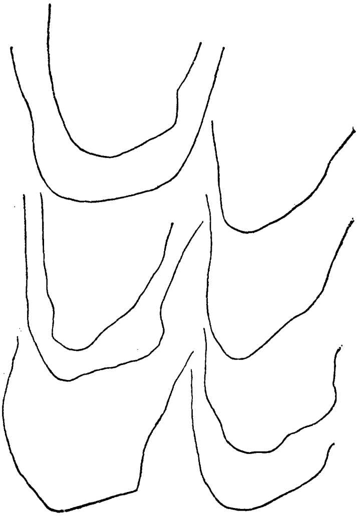

FIG. I.

The vertebral border (Fig. 2).—The most common form of scapula presents a line slightly curved at the lower part, and then straight as far as the root of the spine, from which point it inclines slightly forward till it ends at the upper angle. The forward inclination of the upper part, though varying in degree, is, so far as I know, constant, but the rest of the line varies much. Sometimes it is almost straight, sometimes the whole border of the bone is convex, sometimes the border below the spine is concave. The different types are seen in the annexed diagram, but, better still, in some of the figures of the entire bone.

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[1] By another oversight Broca repeatedly calls this muscle "*le petit rond.*"

The superior border (Fig. 3) is also of uncertain shape. The superior angle cannot be considered apart from the posterior border. The diagrams show its variations so well as to make a description unnecessary. One of these is remarkable as showing the point truncated. None of these, however, show it rounded off in a way that equals the Boschiman scapula figured by Mivart. The variations of this angle are important, because they show that the length of the scapula, as used according to Broca's plan, is liable to vary according to the development of this angle. The bone with the truncated angle has of course a scapular index decidedly different from the one it would have if the posterior and superior borders had been prolonged till they met in a sharp point. The differences in depth of the supra-scapular notch, which ranges from the merest deviation of the course of the superior border to a deep notch and then to a foramen, are well known. I have one specimen in which there is a foramen below a deep notch that is almost bridged over. It is the only case of the kind I have ever seen. The only allusion to its occurrence that I know of is in Humphry's "Human Skeleton."

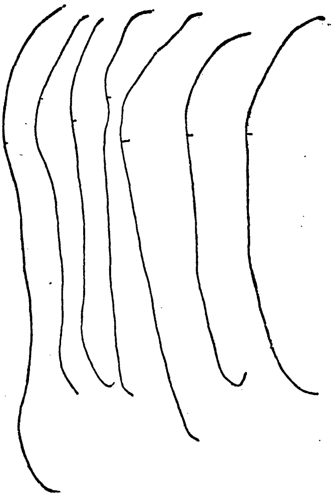

FIG. 2.

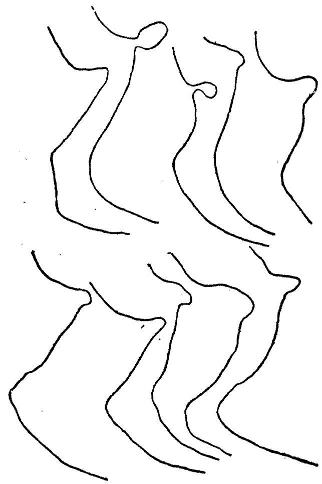

FIG. 3.

Variations in the concavity of the body of the bone should also be mentioned. If a scapula be laid on a table with the ventral surface downward, it will usually rest on three points,—the coracoid, and the superior and inferior angles. The vertebral border, as a rule, forms an arch, the highest point of which is sometimes about 2 cm. from the table. In other cases this border barely leaves the table, and sometimes one or both of the angles mentioned are bent dorsally, so as no longer to be points of support.

On the dorsum the course of the spine and acromion deserve attention. By comparing the scapular and infra-spinous indices we get some idea of its obliquity. A high infra-spinous index with a moderate scapular index shows, of course, a greater obliquity, which is an ape-like peculiarity. When both are very high it shows simply a short, broad scapula. I called attention to the fact that one of the Kentucky mound-builders had a higher scapular index but a lower infra-spinous one than Broca's negro, Tom Blaise, which means that the former had the relatively broader scapula, but the latter the more oblique spine. A study of the one hundred and thirteen Caucasian shoulder-blades shows that the two indices present no great discrepancies. The average scapular index being 63.50 and the infra-spinous 85.83, I find but three with a scapular index of between 64 and 65 which have an infra-spinous index below 85, and of these the lowest was 82.5. I find none at all with a scapular index above 65 and an infra-spinous below 85. Conversely, only seven having an infra-spinous index above 86 have a scapular index below 63. The lowest of these is 61.

Professor Mivart states that when the bone is so held that the long axis of the glenoid cavity is vertical, and that cavity is opposite the eye of the observer, the acromion is almost always higher than the coracoid in man, troglodytes, and hylobates. I do not remember any exception to this rule in man, but I find a good deal of variation in the direction of the line formed by the projecting edge of the acromion when the bone is thus held. It is not easy to determine what angle it forms with the horizon, and I shall give the mean very vaguely, as probably in the neighborhood of 45°, but I have seen it reach at least 65° on one hand and fall to 30° or less on the other. These two extremes are shown in Figs. 12 and 13. I have been unable to find that either of these degrees of inclination is associated with any particular shape of the bone.

The study of the range of variation in these separate parts leads one to the conclusion that very remarkable scapulæ could be constructed by a judicious selection and union of the most striking individual parts; but it would, I think, be difficult to make more remarkable ones than actually occur. I shall now call attention to some of the most curious specimens. Figs. 4 and 5 show respectively the lowest and the highest indices. The breadth is the same in each, but the length of the latter is little more than two-thirds of that of the former. The process for the teres major, though small, is clearly shown on the scapula of the mound-builder, but the other bone has a larger surface for the origin of the muscle, though there is but a slight projection at the anterior edge, which is confirmatory of the views expressed above. Figs. 6 and 7 have already been alluded to as widely different forms, having almost identical indices. Each is a peculiar bone, but the sharp one is the more uncommon. Figs. 8 and 9 are also in strong contrast to each other. The posterior borders have been figured, but the striking effect is shown in the figures of the whole bones. Each is very peculiar and in a different way, though neither has a remarkable index. Fig. 10 represents a wonderfully long bone,[1] being 20 cm. It is a remarkable specimen, and is among those having the lowest indices. The scapular index is 56.5, and the infra-spinous 76.3. The original of Fig. 11 (scapula index 58.8 and infra-spinous 72.3) is figured because it belonged to a negro and yet had indices far below the mean of Caucasian bones. A comparison of these bones shows assuredly remarkable diversities of form. It is easy to find bones of different species of animals that differ less from one another than do these human ones. I am unable to say what remarkable forms might be seen in a large collection of the shoulder-blades of the Felidæ, but I know that a small collection shows no such range. Even the scapula of the bear differs no more from that of the tiger than some of these from one another. A few notes on the anthropoid apes will be found in the appendix.

What influence the height, the muscular development, the health, and the occupation of the individual may have on the shape of the scapula, and indeed on the skeleton in general, cannot as yet be much more than guessed at. The question suggests a field for inquiry, which has as yet hardly been opened, but which in the course of years may bear a rich crop. Something has been done in this direction by Mr. W. Arbuthnot Lane, of London.[1]

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[1] The mate to this bone is the longest I have measured, exceeding it by more than 1 mm., but it has, unfortunately, been injured.

Livon found that in women both indices were higher than in men, while, as above stated, Broca found the reverse, but in very small series. I do not feel convinced that Livon's are large enough to put the fact beyond question, and certainly it would be rash to draw any conclusion as regards a single individual. Probably the actual size of the bone, and more particularly that of the glenoid cavity, are the best indications of the sex that the bone offers, and these are of but little value.

It must be remembered that the great range of individual variation does not necessarily destroy the value of Broca's indices, but it shows that the method must be applied to large series of bones from well-marked races. It is gratifying to find this view supported by no less an authority than Sir William Turner, who writes, "For I gather from my own measurements and those of other observers, that the range of variation in the relative length and breadth of the scapula is very considerable in the same race, so that it needs a large number of bones to enable one to obtain an accurate idea of the mean of any race." [2]

APPENDIX.

THE INDICES OF ANTHROPOID APES.

Both Broca and Flower and Garson published the indices of anthropoid apes in their papers, which have been referred to so often. As the number of observations is necessarily small, I am glad to be able to offer a few additional ones. Broca gives the indices of ten gorilla skeletons, of five chimpanzees, of one orang, and of seven gibbons. Flower and Garson give the indices of sixteen bones of the gorilla, of twenty-one of the chimpanzee, of seventeen of the orang, and of eight of the gibbon.

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[1] The Pathology of Changes produced by Pressure in the Bony Skeleton of the Trunk, Guy's Hospital Reports, vol. xliii., 1886.

[2] It is proper to mention that this paper had been written and sent to the NATURALIST before I had seen Professor Turner's remarks on the scapula in the "Challenger" Reports. Through the courtesy of the editors I have had an opportunity to modify my paper here and there by quoting from his work.

To these I can add the indices of thirteen shoulder-blades of the gorilla, eight of the chimpanzee, and two of the orang.[1]

	Broca.		Flower and Garson.		Dwight.	
	Scap. Ind.	Inf-spin. Ind.	Scap. Ind.	Inf.-spin. Ind.	Scap. Ind.	Inf.-spin. Ind.
Gorilla	70.38	126.05	72.2	132.5	70.1	131.7
Chimpanzee	68.52	130.23	69.9	133.8	68.4	129.1
Orang	69.27	97.46	77.6	103.8	73.6	89.7
Gibbon	96.97	198.56	96.5	201.2		

Below are the highest and lowest indices that I found in gorilla and chimpanzee:

		Scapular Index.	Infra-spinous Index.
Gorilla	Highest	76.6	153.3
	Lowest	66.1	116.0
Chimpanzee	Highest	72.8	136.0
	Lowest	66.1	117.5

These figures show that the highest scapular index of the gorilla and chimpanzee is sometimes, though very rarely, surpassed in human bones. I say nothing of the orang, having measured the bones of only one adult skeleton. The case is different, however, with the infra-spinous index, as the lowest of the gorilla and chimpanzee exceeds the highest human one.

DESCRIPTION OF PLATES.

The views of the dorsum of the scapula are all on the same scale. Figures 12 and 13 are not on precisely the same scale as the others. Figures 6 and 13 are from the same bone. All but 5 and 11 are presumably Caucasian.

		Scapular Index.	Infra-spinous Index.
Fig. 4.		55.1	72.8
" 5.	From Kentucky mounds	82.2	107.3
" 6.		67.8	91.4
" 7.		67.8	90.6
" 8.	Two opposite forms	69.4	97.2
" 9.		61.5	91.4
" 10.	A very long bone	56.5	76.3
" 11.	Negro	58.8	72.3
" 12.	Show extreme degrees of inclination of the acromion.		
" 13.			

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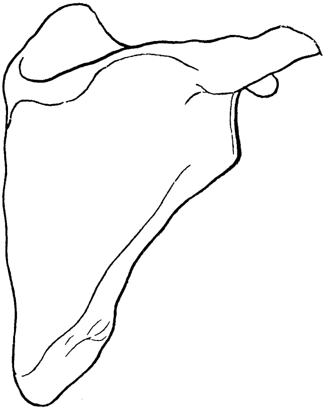
[1] In spite of a foot-note on p. 75 of Broca's paper, I confess to some doubt as to whether his figures of ape measurements refer to the number of skeletons or to the number of scapulæ. I have followed Flower and Garson, who reproduce his table, in stating it as I have in the text. My own figures, like theirs, refer to individual bones.

PLATE XX.



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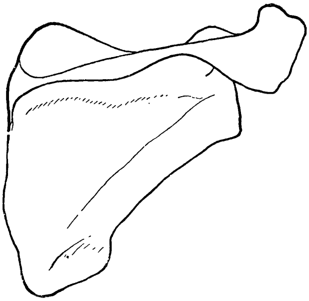

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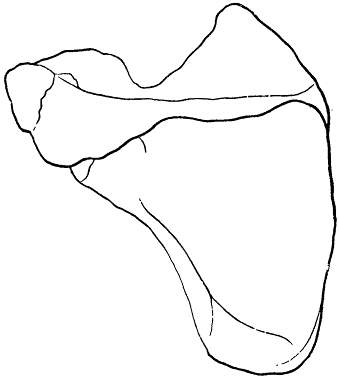

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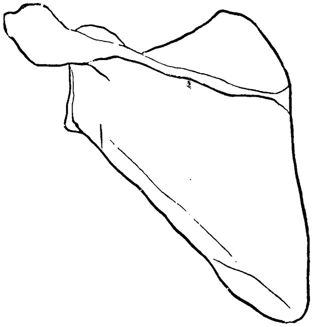

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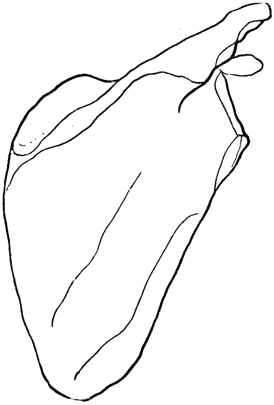

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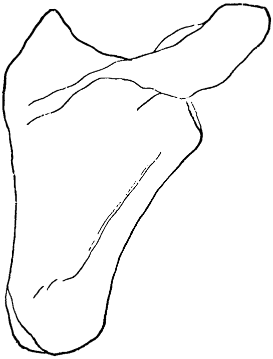

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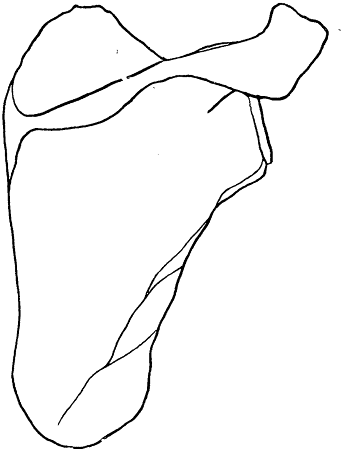
PLATE XXI.



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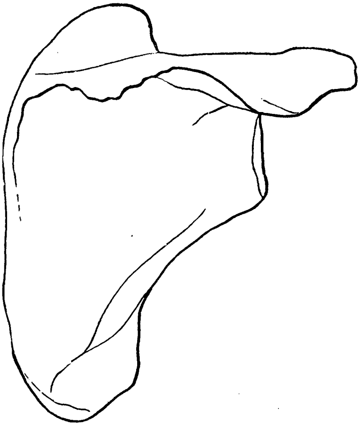
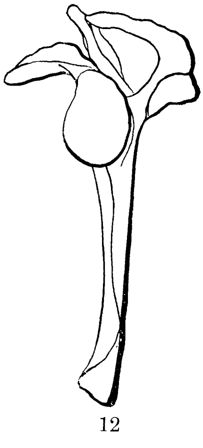
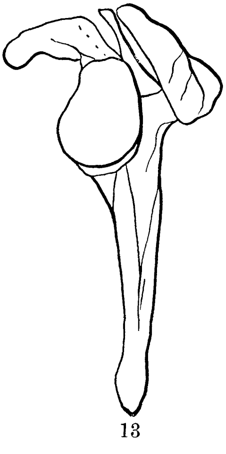


11



12



13